American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Plexopathy**

Variant 1: **Brachial—sudden onset.**

Radiologic Procedure	Rating	Comments	RRL*
MRI neck and/or chest and/or upper extremity without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI neck and/or chest and/or upper extremity without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT neck and/or chest and/or upper extremity without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT neck and/or chest and/or upper extremity without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	Med
X-ray chest	3		Min
X-ray cervical spine	3		Low
FDG-PET whole body	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: **Brachial—chronic.**

Radiologic Procedure	Rating	Comments	RRL*
MRI neck and/or chest and/or upper extremity without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI neck and/or chest and/or upper extremity without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT neck and/or chest and/or upper extremity without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT neck and/or chest and/or upper extremity without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	Med
X-ray cervical spine	4		Low
X-ray chest	3		Min
FDG-PET whole body	2	May be appropriate if malignancy suspected.	High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Plexopathy**

Variant 3: **Brachial—post-traumatic, nonacute.**

Radiologic Procedure	Rating	Comments	RRL*
MRI neck and/or chest and/or upper extremity without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI neck and/or chest and/or upper extremity without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT myelography cervical and/or thoracic spine	6		Med
X-ray myelography cervical and/or thoracic spine	5	Usually performed with CT.	Low
CT neck and/or chest and/or upper extremity without contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	Med
CT neck and/or chest and/or upper extremity without and with contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray chest	3		Min
X-ray cervical spine	3		Low
FDG-PET whole body	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 4: **Brachial—cancer patient. No history of local radiation therapy.**

Radiologic Procedure	Rating	Comments	RRL*
MRI neck and/or chest and/or upper extremity without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI neck and/or chest and/or upper extremity without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
FDG-PET whole body	7	May be useful for staging and characterizing local lesion.	High
CT neck and/or chest and/or upper extremity without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT neck and/or chest and/or upper extremity without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	Med
X-ray chest	4		Min
X-ray cervical spine	3		Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Plexopathy**

Variant 5: **Brachial—cancer patient, post-radiation therapy.**

Radiologic Procedure	Rating	Comments	RRL*
MRI neck and/or chest and/or upper extremity without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI neck and/or chest and/or upper extremity without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
FDG-PET whole body	7	Best imaging tool to distinguish between tumor recurrence and radiation plexopathy.	High
CT neck and/or chest and/or upper extremity without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT neck and/or chest and/or upper extremity without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	Med
X-ray chest	4		Min
X-ray cervical spine	3		Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 6: **Lumbar—sudden onset.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
FDG-PET whole body	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Plexopathy**

Variant 7: **Lumbar—chronic.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	4		Low
FDG-PET whole body	2	May be appropriate if malignancy suspected.	High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 8: **Lumbar—post-traumatic, nonacute.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT abdomen and/or pelvis without contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without and with contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
FDG-PET whole body	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Plexopathy**

Variant 9: **Lumbar—cancer patient. No history of local radiation therapy.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
FDG-PET whole body	7	May be useful for staging and characterizing local lesion.	High
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Variant 10: **Lumbar—cancer patient, post-radiation therapy.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
FDG-PET whole body	7	Best imaging tool to distinguish between tumor recurrence and radiation plexopathy.	High
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Clinical Condition: **Plexopathy**

Variant 11: **Sacral—sudden onset.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
X-ray pelvis AP	3		Min
FDG-PET whole body	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 12: **Sacral—chronic.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	4		Low
X-ray pelvis AP	3		Min
FDG-PET whole body	2	May be appropriate if malignancy suspected.	High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Plexopathy**

Variant 13: **Sacral—post-traumatic, nonacute.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
CT abdomen and/or pelvis without contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without and with contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
X-ray pelvis AP	3		Min
FDG-PET whole body	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 14: **Sacral—cancer patient. No history of local radiation therapy.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
FDG-PET whole body	7	May be useful for staging and characterizing local lesion.	High
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
X-ray pelvis AP	3		Min
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Plexopathy**

Variant 15: **Sacral—cancer patient, post-radiation therapy.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and/or pelvis without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
MRI abdomen and/or pelvis without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	None
FDG-PET whole body	7	Best imaging tool to distinguish between tumor recurrence and radiation plexopathy.	High
CT abdomen and/or pelvis without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
CT abdomen and/or pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	High
X-ray lumbosacral spine	3		Low
X-ray pelvis AP	3		Min
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

PLEXOPATHY

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Summary of Literature Review

Introduction

Plexopathy is the manifestation of abnormal neurological findings by an anatomically defined network of nerves, which are derived from the ventral rami of a set of spinal nerves. Pain (shoulder and arm, or back and leg) with a neuropathic character, dysethesias, burning or electric sensation, occurring in more than one peripheral nerve distribution is characteristic of plexopathy. Pain that radiates in a dermatomal distribution and sensory loss or motor loss in a spinal nerve root distribution are characteristic of radiculopathy.

Complete brachial plexopathy causes weakness, sensory loss, and loss of tendon reflexes in body regions innervated by nerves in the C5-T1 segmental distribution. The clinical diagnosis is confirmed by electrodiagnostic studies (EMG) showing evidence of a neurogenic lesion in muscles innervated by at least two cervical segments involving at least two different peripheral nerves. Lumbar plexopathy produces weakness, sensory loss, and reflex changes in the distribution of spinal segments L2-L4, resulting in weakness and sensory loss in obturator- and femoral-innervated territories. Sacral plexopathy causes the same abnormalities in segments L5-S3, causing weakness and sensory loss in the gluteal (motor only), peroneal, and tibial nerve territories.

Magnetic resonance imaging (MRI) of peripheral nerves at high spatial resolution, with and without fat suppression, has been shown to detect features of intraneural anatomy not previously seen on diagnostic imaging studies and to localize pathologic lesions in conditions where electrophysiologic and physical findings are nonspecific or nonlocalizing [1].

The use of phased arrays and integrated arrays of radiofrequency (RF) coils for dedicated brachial plexus imaging has made it possible to directly evaluate the plexus components—roots, trunks, divisions, and cords—and frequently to distinguish between intrinsic and extrinsic pathological changes.

Evaluation of the plexus focuses on evidence for a mass lesion infiltrating perineural fat and assessment of the intrinsic magnetic resonance (MR) features of nerves, such as signal intensity on short tau inversion recovery (STIR) or fat-saturated T2-weighted fast-spin-echo (FSE) images, the appearance of the intraneural fascicular pattern, and/or the pattern of post-contrast enhancement on fat-saturated T1-weighted images. If an MRI is of diagnostic quality, an accompanying CT study or positron emission tomography (PET) study is only rarely necessary. An exception may be made for post-traumatic brachial plexopathy, for which MRI and post-myelographic CT are complementary in the evaluation of foraminal, paraspinal, and peripheral plexus injuries.

Mastery of anatomy and availability of anatomical references are useful in interpreting studies of the brachial and lumbosacral plexus.

MR Techniques and Image Contrast

The goal is usually to image either the right or left brachial plexus at high spatial resolution; a bilateral examination may also be employed. A comprehensive MRI study of the brachial plexus extends from the roots and trunks, located in the supraclavicular region, to the terminal branches of the cords, located in the infraclavicular region just lateral to the pectoralis minor muscle. For optimal results, the MRI study is targeted to a specific region of the plexus by a careful clinical examination and electrophysiological studies.

The lumbosacral plexus consists of two distinct plexuses, the lumbar and the sacral, with a bridging lumbosacral trunk [2]. The lumbar plexus is usually formed from the L1-L3 ventral rami, with contributions from T12 and L4. The rami constitute the "roots" of the plexus, which divide into anterior and posterior "divisions." In general, the lumbar plexus innervates the muscles of the anterior and medial thigh, while the sacral plexus innervates the muscles of the buttock and posterior thigh, and all those below the knee. The sacral plexus is formed from the ventral rami L4/L5 (lumbosacral trunk) and S1-S4. As with the lumbar plexus, there are anterior and posterior "divisions." The internal iliac vessels are located anteromedial to the lumbosacral trunk at the level of the

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sacral promontory. (Lumbosacral imaging, the goal is to image the left and right lumbar plexus in a single field of view, at the highest possible spatial resolution commensurate with a diagnostic study.)

Pulse Sequences
At field strengths of 1.0 to 1.5 tesla, the plexus is commonly evaluated based on its appearance on T1- and T2-weighted images. Conventional two-dimensional (2D) spin-echo or fast spin-echo (FSE) sequences are used to generate the T1-weighted images, although some investigators prefer T1-weighted 3D gradient-echo images [2,3]. The T1-weighted images display regional anatomy, including the various muscles, blood vessels, and nerves outlined by tissue fat planes. The 2D T2-weighted images are generated with FSE sequences and are useful to detect pathologic changes within components of the plexus. Since abnormal intraneural signal from one component, such as a root or a cord, of the plexus may be obscured by adjacent fat signal, fat suppression is used. The two most common methods are STIR and frequency-selective saturation of the fat resonance.

Contrast-enhanced images of the plexus are obtained routinely in patients being evaluated for suspected neoplasm, radiation injury, inflammation, or abscess formation, and following peripheral nerve surgery. In addition to these indications, contrast-enhanced images have also proven useful in some cases of nerve entrapment and stretch injury. In cases of acute severe traumatic nerve injury and simple compressive neuropathy, a noncontrast exam can be sufficient.

MR Imaging: Normal versus Abnormal Plexus
Abnormal plexus findings include the following: loss of fat planes around all or part of a plexus component, diffuse or focal enlargement of a component (especially, the presence of an eccentric or nodular mass), marked hyperintensity on T2-weighted images and/or enhancement on T1-weighted images with fat suppression. An altered fascicular pattern is also abnormal, although this may not always be apparent. Demonstration of a fascicular pattern may be more difficult for plexus components than for individual peripheral nerves, like the sciatic and tibial nerves, because of the lower spatial resolution of plexus images and because of the difficulty in obtaining true cross-sectional views of most plexus components [1].

Indications for MR Imaging of the Brachial Plexus
A 1994 study by Bilbey et al [4] found conventional spin-echo MRI without gadolinium to be 63% sensitive, 100% specific, and 77% accurate compared to clinicopathologic results in the evaluation of 43 patients with suspected brachial plexopathy. Accuracy increased to 88% when evaluation involved only the subset of patients (n=34) with neoplastic or traumatic disorders. With current high-resolution MRI and the use of gadolinium contrast agents, accuracy is likely to be increased further [5].

Mass Involving the Plexus
MRI can often determine whether a mass is intrinsic or extrinsic to a component nerve of the plexus and, for extrinsic masses, determine the site of the displaced and compressed nerve fibers prior to surgical intervention. Such information is valuable in the diagnosis and management of patients with plexopathy due to neoplastic processes (such as nerve sheath tumors, metastases, direct extension of non-neurogenic primary tumor, and lymphoma) or benign processes (such as aggressive fibromatosis [desmoid tumor] and nodular fasciitis). In a series of 48 reported tumors, 44% were benign and included fibromatosis (most common), lipoma, myositis ossificans, ganglioneuroma, hemangioma, and lymphangioma [6]. The information from MRI aids in preoperative planning and may help to shorten the surgical procedure [6-8].

High-resolution coronal and sagittal images of the symptomatic brachial plexus are especially beneficial in cases where clinical examination and lower resolution imaging studies (covering both right and left plexuses in a single field of view are not able to distinguish whether a patient’s symptoms are due to recurrent tumor, to postoperative or post-treatment changes associated with scarring, or to compressive neuropathy resulting from regional deformity. In patients with plexopathy and Horner's syndrome, axial images are useful to demonstrate paraspinal extension of tumor. If a mass is contiguous with the longus colli muscle, the sympathetic chain is usually invaded. (For lumbosacral imaging, high-resolution coronal and axial images of the bilateral lumbar plexus or sacral plexus are typically obtained.).

Brachial plexopathy caused by metastatic disease is most often seen in patients with carcinoma of the breast or lung. Metastases from breast carcinoma are the most common and involve the plexus mainly by lymphatic spread [9]. Other primary malignancies, such as melanoma, gastrointestinal or genitourinary carcinomas, that metastasized to lymph nodes, soft tissue, or bone and resulted in plexopathy, have been reported [4,9-11].

Lymphoma can involve the plexus in two ways. First, enlarged lymph nodes can compress and/or infiltrate the plexus. Second, neurolymphomatosis, which is a rare manifestation of lymphoma primarily involving the peripheral nerves, can affect the plexus.

The differential diagnosis of infiltrative lesions of the plexus also includes soft tissue tumors, such as sarcomas and fibromatosis [10,12]. Aggressive fibromatosis is a benign fibroblastic proliferation that occurs in the deep

soft tissues, mimics fibrosarcoma, but does not metastasize. It tends to invade or surround muscles, tensions, nerves, and vessels and to recur locally following excision.

The most common neurogenic tumors of the plexus are the benign nerve sheath tumors: neurofibroma (50%-65%), and schwannoma (18%-20%) [13,14]. Malignant peripheral nerve sheath tumors account for 14% of the neurogenic tumors. Nerve sheath tumors may involve any component of the plexus, although the roots are the most frequent site [11].

Malignant peripheral nerve sheath tumors (MPNSTs) occur less frequently than benign tumors, and are found mainly in patients with neurofibromatosis or a history of previous radiation therapy to the brachial plexus region [13,15-17].

Traumatic Injury

Injury to a peripheral nerve due to trauma can range from disruption of axonal conduction with preservation of anatomical continuity of the connective tissue sheaths (neurapraxic injury) to severed nerve with complete loss of continuity of the nerve (neurotmesis injury) [18,19]. By demonstrating the location and severity of injury and the morphology of the injured nerve, high-resolution MRI complements the electrophysiologic studies in determining the exact site and type of nerve injury, and the potential for surgical treatment versus spontaneous recovery. In addition, MRI can show the relationship of the intact nerve to posttraumatic lesions such as spindle, lateral, and stump neuromas, as well as focal or diffuse perineural fibrosis.

Brachial, lumbar, or sacral plexopathy following trauma can result from compression, stretching, or laceration of plexal components, perineural fibrosis, or avulsion of nerve roots from the spinal cord.

It is important to distinguish intraspinal nerve root avulsion (preganglionic lesion) from brachial plexus interruption (postganglionic lesion) since the surgical treatment differs. Nerve root avulsion cannot be repaired directly, and nerotization by nerve-crossing using the intercostal nerves and/or spinal accessory nerve has been recommended [20]. Brachial plexus interruption can be treated by local repair, and nerve grafting is the usual method of plexus reconstruction. Differentiation of nerve root avulsion from plexus injury is aided by EMG studies, since abnormalities of the paraspinal muscles indicate that an injury is proximal to the plexal trunks. Somatosensory evoked potentials have been routinely used to diagnose nerve root avulsion; however, because these do not enable one to discriminate between incomplete avulsion and intact roots, or between intraforminal root avulsion and rootlet avulsion from the spinal cord, the inclusion of imaging studies (myelography, computed tomography (CT) myelography, high-resolution MRI, and MR myelography) in the diagnostic evaluation has been recommended [21,22].

The two major causes of cervical nerve root avulsion are motorcycle accidents and traumatic delivery at birth. In the detection of nerve root avulsion, some studies [21] found that myelography/CT myelography was the most accurate approach (>90%), confirming separate reports of the reliable demonstration of root avulsion with CT myelography [23] and a 92% accuracy of MR myelography compared to CT myelography [24]. Other studies, however, found that myelography/CT myelography and MRI achieved similar accuracy [25]. In the detection of traumatic pseudomeningocele, conventional spin-echo MRI is equivalent to CT myelography, which is more accurate than myelography. For overall characterization of traumatic brachial plexopathy, MRI has an advantage over CT and myelography, because it is better able to show plexus lesions (postganglionic), in addition to detecting pseudomeningocele. Examples of posttraumatic lesions of the plexus that have been demonstrated on spin-echo images include neuromas (tangles of regenerating nerve fibers), focal or diffuse fibrosis, and masses that compress or stretch the plexus, such as hematoma, clavicular fracture, and humeral dislocation [2,4,11,26].

Entrapment Syndromes

Guided to the location of entrapment/compression by the clinical and neurological examination, the MRI study is used to detect objective findings of nerve compression [27]. The brachial plexus and/or the subclavian/axillary artery or vein encounter three possible sites of compression along their course: the interscalene triangle, the costoclavicular space between the first thoracic rib and the clavicle, and the retropectoralis minor space posterior to the pectoralis minor muscle near its insertion on the coracoid process. There is some disagreement regarding the value of MRI in diagnosing neurologic or combined neurovascular thoracic outlet syndrome (TOS) [28,29].

Post-treatment Evaluation

Patients with a history of cancer and clinical evidence of plexopathy following radiation therapy may have, predominantly or exclusively, recurrent tumor or radiation-induced plexopathy. Imaging features that favor recurrent tumor are nonuniform, asymmetric diffuse, or focal enlargement, especially the presence of an eccentric mass with post-contrast enhancement [30,31]. Imaging features that favor post-radiation injury of the brachial plexus are diffuse, uniform, symmetric swelling and T2 hyperintensity of the plexus nerves within the radiation field. Diffuse, uniform post-contrast enhancement for months to years after treatment may also result from

radiation injury [31,32]. Radiation fibrosis often has low signal intensity on T1-weighted and T2-weighted images, [33] and this may represent the more common appearance for chronic radiation injury, although a correlation between the time interval following radiation therapy and T2 signal intensity has not been reported.

When diffuse enlargement, T2 hyperintensity, and post-contrast enhancement of the plexus (as well as surrounding tissues) are present on MRI of patients with a history of breast cancer and radiation therapy, differentiation between radiation injury and local/regional recurrent cancer with axillary/supraclavicular metastases may not be possible. Preliminary results suggest that Flourine-18-2-fluoro-2-deoxy-D-glucose (FDG) PET helps to confirm metastases in patients with indeterminate MRI findings and is useful for depicting metastases outside the axilla [34].

Miscellaneous

When the clinical examination does not reveal an etiology for the patient's neuropathy, MRI may identify a focal or diffuse peripheral nerve or plexus structural abnormality, such as occurs in chronic inflammatory demyelinating polyneuropathy (CIDP) [35,36], multifocal motor neuropathy (MMN) [37], hereditary hypertrophic motor and sensory neuropathies (HMSN) [38,39], and inflammatory pseudotumor [40]. Idiopathic brachial plexus neuritis, or plexitis, presents with sudden onset of severe, constant pain in the lateral neck, shoulder, scapula, or upper arm [41]. Involvement is bilateral in 10%-30% of cases [42,43]. The pain is exacerbated by arm or shoulder movement. In a study by Bilbey et al [4], 4 of 64 consecutive patients who underwent MRI for suspected brachial plexus abnormalities had a clinical diagnosis of idiopathic or viral plexitis. In all four patients, spin-echo MRI findings were normal. Posniak et al [11], reported a case of brachial neuritis in which the nerves of the plexus were diffusely enlarged and hyperintense on T2-weighted images. These findings were attributed to inflammation and edema, but not corroborated by subsequent imaging or other methods.

Conclusion

High-resolution MRI of peripheral nerves and nerve plexuses is an area of rapidly growing clinical interest and importance. The number of studies performed is rapidly increasing in response to the need for more detailed in vivo information about neuropathic changes and regional neural anatomy prior to treatment planning by peripheral nerve specialists [44]. Specific information gained from peripheral nerve imaging studies is being used to determine need for biopsy or surgical treatment. In patients with small tumors, peripheral nerve imaging has proven useful in planning the surgical approach and in predicting the prognosis for preservation of nerve function postoperatively. In cases of traumatic nerve injury, MRI results are being considered as part of the clinical assessment regarding 1) the likelihood of spontaneous recovery versus the need for surgical repair, and 2) the progression of nerve recovery postoperatively.

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Appendix I. Approximate Boundaries for Imaging of Neural Plexuses – Brachial, Lumbar, and Sacral

Brachial plexus, right or left individually, is imaged. Each extends obliquely from paraspinal region (neural foramina) in the neck to the lateral axilla. Superiorly, include the level of the C4 vertebra. Inferiorly, include the level of aortic arch (with spatial presaturation pulses covering arch on MRI). Medially, include spinal canal. Laterally, include axilla lateral to pectoralis minor muscle. Cover from posterior neck (including spinous processes) to anterior neck and axilla (including anterior aspect of first rib).
Lumbar plexus, right and left together are imaged. Each plexus follows an oblique course from the lumbar paraspinal region (neural foramina) to and within the ipsilateral psoas muscles. Superiorly, include the level of the T12 vertebra. Inferiorly, include the level of the S2 vertebra. Cover from the posterior surface of the lower back to the anterior borders of the psoas muscles.
Sacral plexus, right and left together are imaged. Each plexus is primarily located anterior to the piriformis muscle and follows an infero-anterolateral course from the lumbosacral foramina to the ipsilateral greater sciatic foramen. Superiorly, include the level of the L4 vertebra. Inferiorly, include the level of the greater sciatic foramen (approximately S4-5 in the transverse plane). Cover from posterior surface of sacrum and the gluteal muscles to the anterior aspect of the pelvis.